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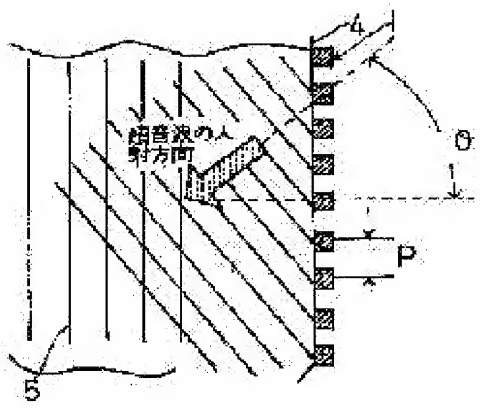
(54) ULTRASONIC WASHER

(57)Abstract:

PROBLEM TO BE SOLVED: To perform uniform and sure washing by inputting ultrasonic waves from ultrasonic vibrator transducers to a lot of materials to be washed arranged side by side in a washing tank at an inclined angle θ at which permeability is about 100%.

SOLUTION: Ultrasonic vibrator transducers 1 are arranged in an array on the side face of a washing tank 4, spaced P (P = λ/sinθ, where λ = ultrasonic wave length, and θ = inclined angle at about 100% permeability) apart to make ultrasonic vibration elastic waves of an inclined angle θ incident on materials to be washed 5 in the washing tank 4. In this way, a lot of the materials to be washed are all washed almost uniformly and surely.



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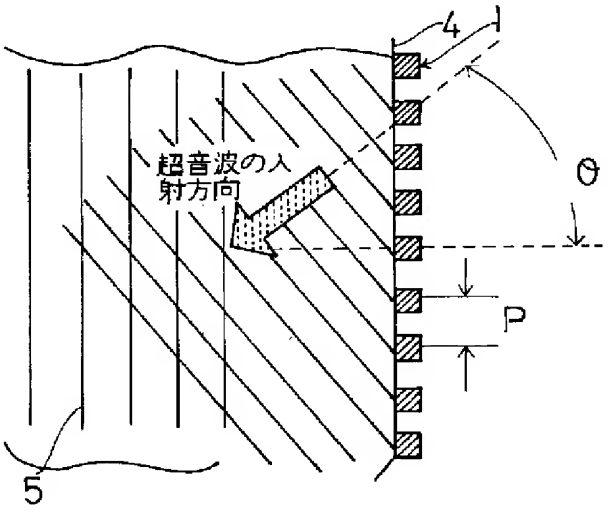
(54)【発明の名称】　超音波洗浄装置

(57)【要約】
【課題】　透過率が約１００［％］になる傾斜角θで洗浄槽内に並置される多数枚の被洗浄物に超音波振動子からの超音波を入力し、均一で、且つ確実な洗浄を行なう超音波洗浄装置を提供する。
【解決手段】　洗浄槽４の側面に間隔Ｐ＝λ／ｓｉｎθ（λは超音波の波長，θは透過率約１００［％］の傾斜角）で超音波振動子１をアレイ状に配置し、洗浄槽４内の被洗浄物５に傾斜角θの超音波振動弾性波を入射する。これにより、多数枚の被洗浄物のすべてがほぼ均一に、且つ確実に洗浄される。



【特許請求の範囲】
【請求項１】　板状の被洗浄物と洗浄液とを収容する洗浄槽に波長λの超音波振動を発生する超音波振動体が配置されており、前記洗浄液内を伝搬する前記超音波振動の伝搬方向が、前記被洗浄物に斜めに交差し、且つ該被洗浄物の受波面の法線方向に対する傾斜角θが該被洗浄物を透過する前記超音波振動の振動エネルギーの透過率が著しく改善される角度範囲になるように構成された超音波洗浄装置において、前記超音波振動体は、前記被洗浄物と平行に配置され、且つ以下の関係式を満たす間隔Ｐで配列した振動子の集合体からなることを特徴とする超音波洗浄装置。
Ｐ＝λ／ｓｉｎθ
【請求項２】　板状の被洗浄物と洗浄液とを収容する洗浄槽に波長λの超音波振動を発生する超音波振動体が配置されており、前記洗浄液内を伝搬する前記超音波振動の伝搬方向が、前記被洗浄物に斜めに交差し、且つ該被洗浄物の受波面の法線方向に対する傾斜角θが該被洗浄物を透過する前記超音波振動の振動エネルギーの透過率が著しく改善される角度範囲になるように構成された超音波洗浄装置において、前記超音波振動体は、前記被洗浄物と平行に配置され、且つ以下の関係式を満たす間隔Ｐで配列した振動子の集合体からなることを特徴とする超音波洗浄装置。
Ｐ≦λ／ｓｉｎθ
【請求項３】　前記間隔Ｐで配列された各振動子とこれらに駆動信号を供給する信号供給源との間には各振動子に入力される駆動信号の位相を調整する超音波発生用位相変換回路が介設されることを特徴とする請求項２に記載の超音波洗浄装置。
【請求項４】　板状の被洗浄物と洗浄液とを収容する洗浄槽に超音波振動を発生する超音波振動体が配置されており、音速Ｖで前記洗浄液内を伝搬する前記超音波振動の伝搬方向が、前記被洗浄物に斜めに交差し、且つ前記被洗浄物の受波面の法線方向に対する傾斜角θが前記被洗浄物を透過する前記超音波振動の振動エネルギーの透過率が著しく改善される角度範囲になるように構成された超音波洗浄装置において、前記超音波振動体は、前記被洗浄物と平行に配置された振動板と、これに取り付けられた一個以上の発振素子とからなり、該発振素子は、以下の関係式を満たす位相速度ｖで前記振動板に沿って弾性漏洩波を励起し、これにより所望の前記傾斜角θで超音波振動を前記被洗浄物に印加することを特徴とする超音波洗浄装置。
ｖ＝Ｖ／ｓｉｎθ
【請求項５】　前記振動板が、前記洗浄槽内に配置され、前記振動板を挟んで前記被洗浄物が配置されることを特徴とする請求項４に記載の超音波洗浄装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、溶液中の被洗浄物に強力な超音波を照射して洗浄を行う超音波洗浄装置に関する。
【０００２】
【従来の技術】一般に超音波洗浄装置と呼ばれるものには２種類あり、キャビテーションによるものと流水式のものとがある。前者は、強力な超音波を洗浄液中に伝搬させる際に発生する微小な真空泡がある瞬間に消滅することによって生ずる強力な衝撃波を用いて被洗浄物の表面の汚物等を除去するものである。キャビテーションは高周波では起りにくいため、この洗浄方法は精々数百ＫＨｚ以下の低周波で行われる。一方、後者の流水式のものは比較的高いＩＭＨｚ以上の周波数の超音波を滝状に被洗浄物に流下する水流に伝搬させて、被洗浄物の表面に超音波エネルギーを印加して汚れを洗浄除去するものである。この方法は前記のキャビテーションによる洗浄のように被洗浄物に大きな力を印加しないため被洗浄物へのダメージが少なく、比較的微細な、例えばマイクロメータオーダの加工品の例えば半導体ウエハ等の洗浄に適するものである。
【０００３】
【発明が解決しようとする課題】前記した超音波洗浄装置により、被洗浄物の洗浄は可能であるが、数多くの被洗浄物を洗浄槽内に収容し、同時に洗浄する場合には次のような問題点がある。図９は複数個の板状の被洗浄物５を適宜間隔を介して並置させた状態で洗浄槽４ａ内に収容し、被洗浄物５の洗浄面（受波面）８と直交して超音波発振体９を配置したものである。この場合、矢印のように、超音波発振体９から受波面８に沿う超音波振動が発生し、受波面８の両面が同時に洗浄される。然し乍ら、この場合、超音波発振体９に近接している被洗浄物５の受波面８は洗浄されるが、離れるに従って超音波振動が減衰し、十分な振動エネルギーを被洗浄物５に印加できず洗浄が不十分となる結果を招く。なお、この減衰性は周波数が高くなるに従って強い。
【０００４】一方、図１０に示すように、洗浄槽４ａの側面に超音波発振体９を配置し、これと平行に配されている被洗浄物５を洗浄する場合には超音波振動が被洗浄物５に直角に当り、印加部分は強力に洗浄される。然し乍ら、被洗浄物５に直角に入射された超音波はその受波面８で反射され、被洗浄物５を透過する超音波振動の振動エネルギーは大巾に減少する。そのため、超音波発振体９に近接して配置されている被洗浄物５は十分に洗浄されるが離れた基板の洗浄が不十分となる問題点がある。
【０００５】超音波振動の伝搬効率を改善した洗浄装置が提案されており、例えば、特開平４－８７６７５号公報に開示されている。以下、簡潔に説明する。図７は横軸に被洗浄物５の受波面８の法線方向に対する超音波振動の入射方向の傾斜角θ（°）と、被洗浄物５を透過す

る超音波振動エネルギーの透過率［％］との関係を示す線図である。図示のように、θの値がある角度範囲では透過率が極端に大きくなる。即ち、図示の場合、θが約２０［°］から３０［°］の範囲に透過率約１００［％］のピーク値がある。従って、この範囲の傾斜角θで超音波振動を被洗浄物５に印加すると超音波振動の振動エネルギーは減衰しないで順次並設しているすべての被洗浄物５に印加され、十分な洗浄が行われる。なお、この特定の傾斜角θは被洗浄物５の板厚，材質，入射される超音波振動の周波数，被洗浄物や洗浄液の弾性定数等の関数として求められる。

【０００６】図８は洗浄槽４ｂの一側面を角度θだけ傾斜して傾斜部に超音波発振体９を固定したものである。被洗浄物５は洗浄槽４ｂ内に複数枚並置される。前記傾斜角θを図７に示したピーク角度範囲のθに設定することにより、被洗浄物５に対する超音波振動エネルギーの透過率が大きくなるため、複数枚の被洗浄物５の夫々に対して超音波発振体９から十分な振動エネルギーが印加されて確実、且つ十分な洗浄が行われる。然し乍ら、この場合には次のような問題点がある。即ち、被洗浄物５と超音波発振体９との間の間隔は図において被洗浄物５の下方に行くに従って広くなるため被洗浄物５に対する振動エネルギーの印加度合が低減し、受波面８が均一に洗浄されなくなる問題点がある。また、被洗浄物５の寸法が長くなると、それにつれて超音波発振体９を延長する必要があり、且つ両者の間隔が増々大きくなる問題点がある。また、角度θは洗浄槽４ｂの一側面の傾斜角として固定的に設定されるものであり、被洗浄物５の板厚や材質等が異なるとそれに伴って洗浄槽４ｂ自体の形状を変更する必要があり、極めて煩雑であり、設備コストもかかる。

【０００７】本発明は、以上の事情に鑑みて創案されたものであり、単一の洗浄槽により多数枚の被洗浄物を同時に確実且つ十分に洗浄でき、数ＭＨｚ以上の周波数の超音波洗浄が可能であり、大型のウエハやガラス基板等の洗浄を十分に行う振動エネルギーを用いた比較的設備コストがかからない超音波洗浄装置を提供することを目的とする。

【０００８】

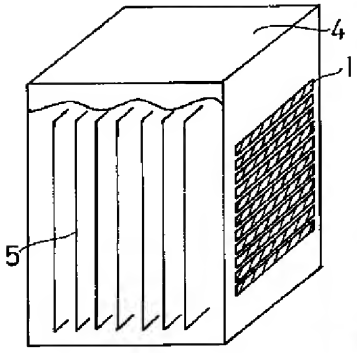
【課題を解決するための手段】本発明は、以上の目的を達成するために、板状の被洗浄物と洗浄液とを収容する洗浄槽に波長λの超音波振動を発生する超音波振動体が配置されており、前記洗浄液内を伝搬する前記超音波振動の伝搬方向が、前記被洗浄物に斜めに交差し、且つ該被洗浄物の受波面の法線方向に対する傾斜角θが該被洗浄物を透過する前記超音波振動の振動エネルギーの透過率が著しく改善される角度範囲になるように構成された超音波洗浄装置において、前記超音波振動体は、前記被洗浄物と平行に配置され、且つＰ＝λ／ｓｉｎθの式或はＰ≦λ／ｓｉｎθを満足する間隔Ｐで配列した振動子の集合体からなる超音波洗浄装置を構成するものである。また、前記間隔Ｐで配列された各振動子とこれらに駆動信号を供給する信号供給源との間には各振動子に入力される駆動信号の位相を調整する超音波発生用位相変換回路が介設される超音波洗浄装置を特徴とする。また、板状の被洗浄物と洗浄液とを収容する洗浄槽に超音波振動を発生する超音波振動体が配置されており、音速Ｖで前記洗浄液内を伝搬する前記超音波振動の伝搬方向が、前記被洗浄物に斜めに交差し、且つ前記被洗浄物の受波面の法線方向に対する傾斜角θが前記被洗浄物を透過する前記超音波振動の振動エネルギーの透過率が著しく改善される角度範囲になるように構成された超音波洗浄装置において、前記超音波振動体は、前記被洗浄物と平行に配置された振動板と、これに取り付けられた一個以上の発振素子とからなり、該発振素子はｖ＝Ｖ／ｓｉｎθの式を満たす位相速度ｖで前記振動板に沿って弾性漏洩波を励起し、これにより、所望の前記傾斜角θで超音波振動を前記被洗浄物に付加することを特徴とする。また、前記振動板が、前記洗浄槽内に配置され、前記振動板を挟んで前記被洗浄物が配置されることを特徴とする。

【０００９】本発明の第一側面によれば、洗浄槽に波長λの超音波振動を発生する超音波振動体は複数の振動子を間隔Ｐで配列したアレイを用いている。透過率のピークを示す全透過角θを基にしてＰ＝λ／ｓｉｎθの式から求められる間隔Ｐで各振動子を並べることにより、これ等の集合体としての超音波振動体からはスネルの法則により被洗浄物の受波面の法線方向に対して角度θの超音波振動の弾性波を印加することができる。この弾性波は傾斜角θで洗浄槽内を進行する一方、超音波振動体自体は被洗浄物に対し平行に配置できるため被洗浄物の寸法が長くなっても超音波振動と被洗浄物との間隔は一定になる。また、被洗浄物の板厚や材質等が変化した場合は、それ等に対応する全透過角θを基にしてＰ＝λ／ｓｉｎθで求めた間隔Ｐで超音波振動体を配列変更すればよい。また、Ｐ≦λ／ｓｉｎθに示すように、アレイの振動素子の間隔を小さく形成すると共に、各超音波振動子に印加される発振用電気信号の位相を相対的に調整すれば、任意の角度に十分な精度をもって被洗浄体に超音波エネルギーを照射することができる。また、本発明の第二の側面によれば、前記の超音波振動体アレイの替りに振動板とこれに取り付けられた発振素子を洗浄槽の内部又は外側壁に設けることにより、ｖ＝Ｖ／ｓｉｎθで求められる位相速度ｖの漏洩波を励起し、この漏洩波から被洗浄物に角度θで印加される超音波振動が発生するため前記の振動子アレイを用いたものと同様に確実、且つ十分な洗浄が行われる。この場合被洗浄物の板厚や材質に応じた角度θの変化に伴って位相速度ｖを変化するように発振素子の発振条件を変化させれば一台の洗浄装置で種々の板状物品の超音波洗浄に対応できる。

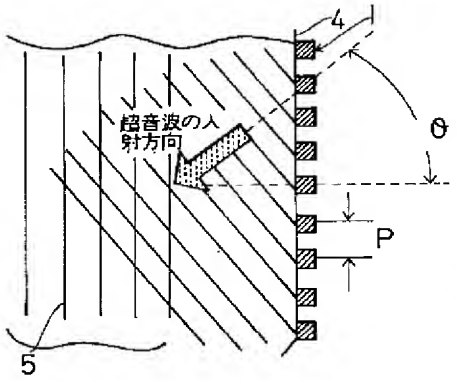
【００１０】
【発明の実施の形態】以下、本発明の超音波洗浄装置を図面を参照して詳述する。図１におよび図２に示すように、箱体状の洗浄槽４の内部の洗浄液内には板状の被洗浄物５が多数枚並置される。洗浄槽４の平坦な一側面には間隔Ｐで多数個の超音波振動子１がアレイ状に配置されており、全体として超音波振動体を構成する。各超音波振動子１から発振される超音波振動の波長をλとし、各超音波振動子に印加される電気信号が同位相とすると、波長λと間隔Ｐと角度θとの間にはＰ＝λ／ｓｉｎθの関係式が成立する。角度θは被洗浄物５の受波面の法線方法に対する超音波振動の傾斜角である。この傾斜角（入射角）θを図７に示した透過率が約１００［％］になる角度範囲に設定し、これに見合うＰを求める。なお、傾斜角θは被洗浄物５の板厚，材質，照射される超音波振動の周波数や被洗浄物と洗浄液の弾性定数（密度，音速等）等の関数として理論的，実験的に求められるものであり、全透過角と呼ばれる。実際には傾斜角θを正確に全透過角に一致させる必要はなく、一定の角度範囲で所望の効果が得られる。
【００１１】個々の超音波振動子１を図１，図２のように間隔Ｐで配置し、超音波振動子１を駆動すると、洗浄槽４内には図２に示すように傾斜角θの超音波振動が生じ被洗浄物５に振動エネルギーが印加される。この超音波振動のエネルギーは透過率が１００［％］に近いため、夫々の被洗浄物５を減衰しないで透過し、被洗浄物５のすべての洗浄を行なうことができる。勿論、被洗浄物５の表裏の洗浄が可能である。被洗浄物５の形状，材質等が変化した場合には、これに見合う傾斜角θが生ずるように間隔Ｐを変えて超音波振動子１を配置すればよい。また、図８に示した従来技術のものと異なり、被洗浄物５の受波面８に対して超音波振動子１のアレイを平行に配置できるため、常に均一の振動エネルギーを被洗浄物５の全面に印加し、均一の洗浄を行なうことができる。
【００１２】前記の各超音波振動子１には原信号供給源（図示せず）から位相変換回路を介すことなく周波数ｆの駆動信号が均一に入射されるため夫々の超音波振動子１からは位相遅れのない弾性波が洗浄槽４内に送られる。図５，図６は夫々の超音波振動子１に印加される電気信号の位相を変えて、洗浄槽４内に送られる超音波に位相ずれを与える実施の形態の一例を示す。位相ずれを与えることにより、被洗浄物５に対し、波状的に弾性波の振動エネルギーを印加し、より、洗浄効果の確実化が図られる。また、このような位相変換回路を用いれば、超音波振動子の間隔Ｐを小さくしてより高精度に意図した角度に指向性の高い超音波を被洗浄体表面に照射することができる。
【００１３】図５に示すように、原信号供給源（図略）からは周波数ｆの原信号が送られる。前記原信号供給源と洗浄槽４に設けた各超音波振動子１との間には超音波発生用位相変換回路６が介設される。この超音波発生用位相変換回路６は原信号に対し、位相Δｔのずれを生じさせて各超音波振動子１に駆動信号を印加する機能を有するものである。図５，図６に示すように、❶の超音波振動子１にはΔｔ＝０の原信号をそのままの駆動信号として入力し、❷の超音波振動子１にはΔt_1＝Δｔだけ位相シフトした駆動信号が入力される。同様に❸の超音波振動子１にはΔt_2＝２Δｔ，❹の超音波振動子１にはΔt_3＝３Δｔだけシフトした駆動信号が送られる。勿論、図示以外の超音波振動子１にも順次Δt_4，Δt_5・・・だけ位相シフトした駆動信号が入力される。なお、位相シフト量Δｔは各超音波振動子１の配列ピッチのＰと洗浄液の音速Ｖを用いてΔｔ＝（Ｐ／Ｖ）・ｓｉｎθと表わされる。以上により、各超音波振動子１からは位相調整された超音波振動の弾性波が傾斜角度θで出射され被洗浄物５に印加される。
【００１４】図３は本発明の別の実施の形態を示す。本例の洗浄槽４は厚さｄの側面板を振動板３として利用している。振動板３上には発振素子２が取り付けられており、全体として超音波振動体を構成している。振動板３上で発振素子２が振動すると、振動板３には位相速度ｖの漏洩波７が励起する。この漏洩波７（例えば、漏洩ラム波）は洗浄槽４の槽内に傾斜角θの超音波振動の弾性波を発生する。洗浄液内を伝搬する超音波振動の音速をＶとした場合、前記漏洩波の位相速度ｖはｖ＝Ｖ／ｓｉｎθにより求められる。従って、被洗浄物５に対する振動エネルギーの透過率を約１００［％］にする傾斜角θに応じて所望の位相速度ｖの漏洩波を励起する発振素子２の発振条件を決めればよい。本例の洗浄装置によっても前例とほぼ同様の効果を上げることができる。
【００１５】図４は図３に示した実施の形態の応用例である。本例では、洗浄槽４の内部に振動板３ａを配置し、これに発振素子２を連結したものである。この場合、被洗浄物５は振動板３ａを挟んで両側に配置される。本例の場合も振動板３ａに漏洩波７が発生し、その両側から傾斜角θで超音波振動の弾性波が発せられ、両側の被洗浄物５を均等に洗浄することができる。ここでは、振動板は一個の発振素子による片持ちばり構造をとっているが、振動板の対面にもう一個の発振素子を設けることで、更に均一で強力な超音波を被洗浄物に加えることが可能になる。
【００１６】
【発明の効果】１）本発明の請求項１に記載の超音波洗浄装置によれば、洗浄槽にアレイ状に間隔Ｐ＝λ／ｓｉｎθで超音波振動子を配置することにより、被洗浄物に透過率約１００［％］の弾性波が傾斜角θで印加され、多数枚の被洗浄物の表面が確実に、且つ十分に洗浄される。また、被洗浄物に近接して、且つ均一に数ＭＨｚ以上の周波数の超音波を被洗浄物に照射することができ、

洗浄度の向上が図れる。
２）本発明の請求項２および請求項３に記載の超音波洗浄装置によれば、各超音波振動子から発せられる弾性波が位相調整されているため確実な洗浄が行われる。
３）本発明の請求項４に記載の超音波洗浄装置によれば、洗浄槽に設けた振動体に位相速度ｖ＝Ｖ／ｓｉｎθの漏洩波を励起し、この漏洩波から被洗浄物に傾斜角θの弾性波を入射し、傾斜角θを透過率約１００［％］の全透過角近傍に設定することにより、多数枚の被洗浄物が確実に、且つ十分に洗浄される。
４）本発明の請求項５に記載の超音波洗浄装置によれば、振動体を直接洗浄槽内に入れることにより、より均等且つ効率的な洗浄が行われる。
【図面の簡単な説明】
【図１】箱体状の洗浄槽の側面にアレイ状に配置された超音波振動子を示す斜視図。
【図２】図１における超音波振動の伝搬状態を示す模式図。
【図３】洗浄槽の側面に振動板と発振素子を設けて漏洩波を励起し、槽内に超音波振動を伝搬させる状態を示す模式図。
【図４】図３における振動板を洗浄槽内に配置した実施の形態を示す模式図、
【図５】周波数ｆの原信号を超音波振動子に位相シフトした駆動信号に変換して各超音波振動子に入力させるための構成図。
【図６】図５における位相シフトした駆動信号の一例を示す波形図。
【図７】被洗浄物に照射される超音波振動の傾斜角と透過率との関係を示す線図。
【図８】従来の傾斜角θを用いた洗浄方法の一例を示す断面図。
【図９】従来の洗浄方法を示す模式図。
【図１０】従来の洗浄方法を示す模式図。
【符号の説明】
１　超音波振動子
２　発振素子
３　振動板
３ａ　振動板
４　洗浄槽
５　被洗浄物
６　超音波発生用位相変換回路
７　漏洩波
８　受波面
９　超音波発振体

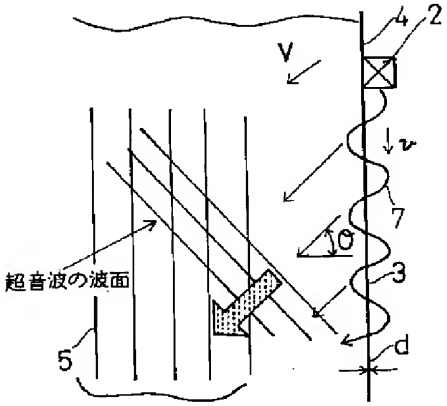
【図１】



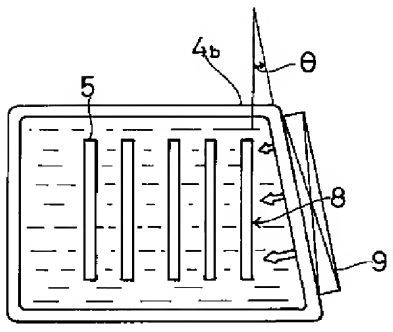
【図２】



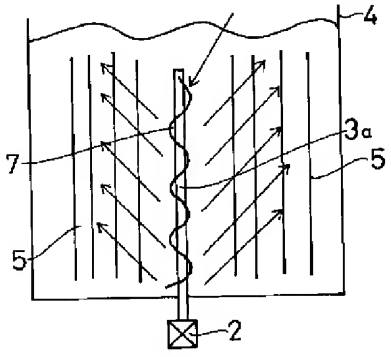
【図３】



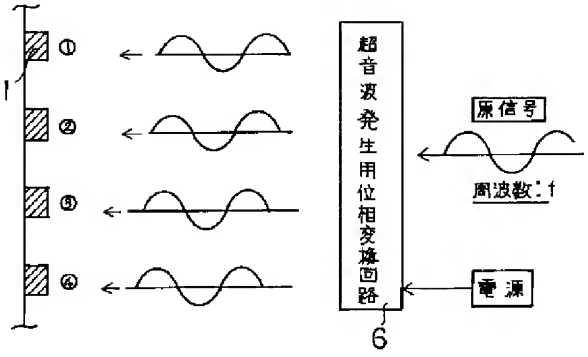
【図８】



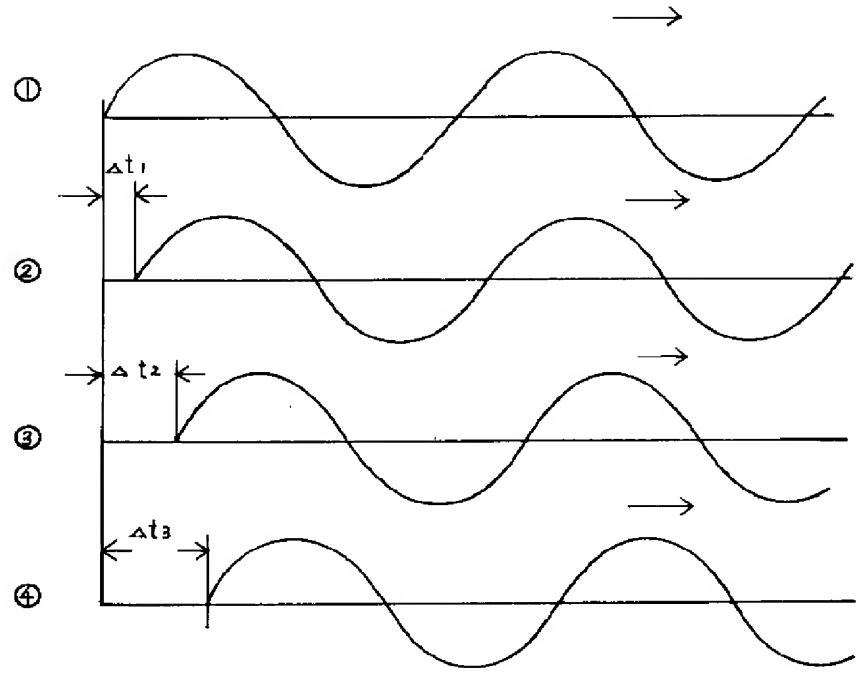
【図４】



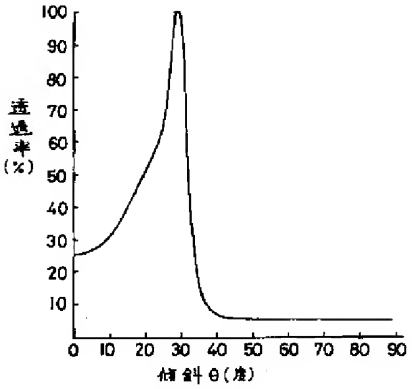
【図５】



【図６】



【図７】



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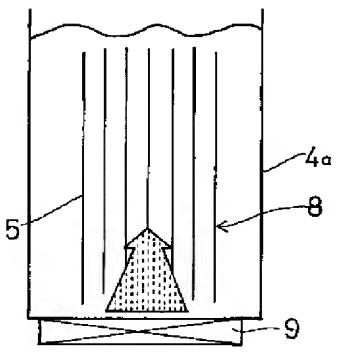
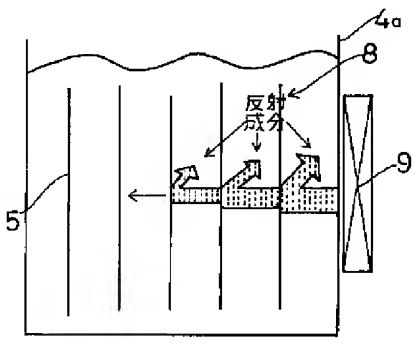


【図１０】



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CLAIMS

[Claim(s)]
[Claim 1]An ultrasonic vibration body which generates supersonic vibration of the wavelength lambda in a cleaning tank in which a tabular washed object and a penetrant remover are accommodated is arranged, A propagating direction of said supersonic vibration which spreads inside of said penetrant remover intersects said washed object aslant, And in an ultrasonic cleaner constituted so that transmissivity of vibrational energy of said supersonic vibration with which the angle of inclination theta to a normal line direction of a wave receiving surface of this washed object penetrates this washed object might become an angle range improved remarkably, An ultrasonic cleaner, wherein said ultrasonic vibration body consists of an aggregate of a vibrator arranged at intervals of P which is arranged at said washed object and parallel, and fills the following expressions of relations.
P=lambda/sintheta [Claim 2]An ultrasonic vibration body which generates supersonic vibration of the wavelength lambda in a cleaning tank in which a tabular washed object and a penetrant remover are accommodated is arranged, A propagating direction of said supersonic vibration which spreads inside of said penetrant remover intersects said washed object aslant, And in an ultrasonic cleaner constituted so that transmissivity of vibrational energy of said supersonic vibration with which the angle of inclination theta to a normal line direction of a wave receiving surface of this washed object penetrates this washed object might become an angle range improved remarkably, An ultrasonic cleaner, wherein said ultrasonic vibration body consists of an aggregate of a vibrator arranged at intervals of P which is arranged at said washed object and parallel, and fills the following expressions of relations.
P<=lambda/sintheta [Claim 3]The ultrasonic cleaner according to claim 2, wherein a phase conversion circuit for ultrasonic wave generations which adjusts a phase of a driving signal inputted into each vibrator between said each vibrator arranged at intervals of P and a signal supply source which supplies a driving signal to these is interposed.
[Claim 4]Have the following and this oscillation element excites an elastic leaky wave along with said diaphragm with the phase velocity v which fills the following expressions of relations, . It is characterized by this impressing supersonic vibration to said washed object with said desired angle of inclination theta. An ultrasonic vibration body which generates supersonic vibration in a cleaning tank in which a tabular washed object and a penetrant remover are accommodated is arranged, A propagating direction of said supersonic vibration which spreads inside of said penetrant remover at the acoustic velocity V intersects said washed object aslant, And an

ultrasonic cleaner constituted so that transmissivity of vibrational energy of said supersonic vibration with which the angle of inclination theta to a normal line direction of a wave receiving surface of said washed object penetrates said washed object might become an angle range improved remarkably.

A diaphragm by which said ultrasonic vibration body has been arranged at said washed object and parallel.

An oscillation element more than a piece attached to this.

v=V/sintheta [Claim 5]The ultrasonic cleaner according to claim 4, wherein said diaphragm is arranged in said cleaning tank and said washed object is arranged on both sides of said diaphragm.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the ultrasonic cleaner which washes by irradiating the washed object in a solution with a powerful ultrasonic wave.
[0002]
[Description of the Prior Art]The thing of a stream type is one of those which are generally called an ultrasonic cleaner as some which are depended on those with two kind, and a cavitation. The former removes the filth of the surface of a washed object, etc. using the powerful shock wave produced by disappearing the moment there is a minute vacuum bubble by which it is generated when making a powerful ultrasonic wave spread in a penetrant remover. Since a cavitation does not happen easily in high frequency, this cleaning method is performed by a low frequency wave of at most hundreds of kHz or less. On the other hand, the stream which flows down the ultrasonic wave of the frequency more than comparatively high IMHz to a washed object in the shape of a waterfall is made to spread the thing of the latter stream type, it impresses ultrasonic energy on the surface of a washed object, and carries out washing removal of the dirt. In order that this method may not impress big power to a washed object like washing by the aforementioned cavitation, there are few damages to a washed object, and it is comparatively detailed, for example, suitable for washing of the processed goods of micrometer order, for example, a semiconductor wafer etc.
[0003]
[Problem(s) to be Solved by the Invention]Although washing of a washed object is possible with the above mentioned ultrasonic cleaner, in accommodating many washed objects in a cleaning tank and washing them simultaneously, there are the following problems. Drawing 9 is accommodated in the cleaning tank 4a in the state where two or more tabular washed objects 5 were made to juxtapose via an interval suitably, intersects perpendicularly with the cleaning surface (wave receiving surface) 8 of the washed object 5, and arranges the ultrasonic oscillation object 9. In this case, the supersonic vibration which meets the wave receiving surface 8 from the ultrasonic oscillation object 9 occurs like an arrow, and both sides of the wave receiving surface 8 are washed simultaneously. However, although washed, supersonic vibration decreases the wave receiving surface 8 of the washed object 5 which is close to the ultrasonic oscillation object 9 in ** et al. and this case as it is left, and it cannot impress sufficient

vibrational energy to the washed object 5, but causes the result it becomes insufficient washing. This attenuation nature is strong as frequency becomes high.

[0004]On the other hand, as shown in drawing 10, the ultrasonic oscillation object 9 is arranged on the side of the cleaning tank 4a, in washing the washed object 5 arranged on this and parallel, supersonic vibration hits the washed object 5 right-angled, and an impression portion is washed powerfully. However, the ultrasonic wave which entered right-angled is reflected by ** et al. and the washed object 5 in the wave receiving surface 8, and the vibrational energy of the supersonic vibration which penetrates the washed object 5 decreases sharply. Therefore, there is a problem it becomes insufficient [the washed object 5 arranged by approaching the ultrasonic oscillation object 9] washing of the substrate which separated although fully washed.

[0005]The washing station which has improved the propagation efficiency of supersonic vibration is proposed, for example, it is indicated by JP,4-87675,A. Hereafter, it explains briefly. Drawing 7 is a diagram showing a relation with the transmissivity [%] of the ultrasonic vibration energy which penetrates the washed object 5 on a horizontal axis with angle-of-inclination [of the incidence direction of supersonic vibration] theta (degree) to the normal line direction of the wave receiving surface 8 of the washed object 5. Like a graphic display, transmissivity becomes extremely large in an angle range with the value of theta. That is, in a graphic display, the peak value of the transmissivity 100 [about] [%] has theta in the range of about 20 [**] to 30 [**]. Therefore, if supersonic vibration is impressed to the washed object 5 with the angle of inclination theta of this range, the vibrational energy of supersonic vibration will be impressed to all the washed objects 5 currently installed side by side one by one without decreasing, and sufficient washing will be performed. This specific angle of inclination theta is called for as functions, such as board thickness of the washed object 5, construction material, frequency of the entering supersonic vibration, a washed object, an elastic constant of a penetrant remover.

[0006]Only the angle theta inclines the one side face of the cleaning tank 4b, and drawing 8 fixes the ultrasonic oscillation object 9 to an inclined part. Two or more washed objects 5 are juxtaposed in the cleaning tank 4b. Since the transmissivity of the ultrasonic vibration energy to the washed object 5 becomes large by setting said angle of inclination theta as theta of the peak angle range shown in drawing 7, sufficient vibrational energy is impressed from the ultrasonic oscillation object 9 to each of the washed object 5 whose number is [two or more], and certain and sufficient washing is performed. However, there are ** et al. and the problems following in this case. That is, in a figure, since [which is the washed object 5] it becomes large as it goes caudad, the impression degree of vibrational energy to the washed object 5 reduces the interval between the washed object 5 and the ultrasonic oscillation object 9, and there is a problem that the wave receiving surface 8 is no longer washed uniformly. moreover -- if the size of the washed object 5 becomes long, it is necessary to extend the ultrasonic oscillation object 9 along with it -- and both interval -- **** -- there is a problem which becomes large. The angle theta is set up fixed as an angle of inclination of the one side face of the cleaning tank 4b, if it differs in board thickness, construction material, etc. of the washed object 5, it needs to change the shape of the cleaning tank 4b itself in connection with it, is very complicated and also requires facility cost.

[0007]It is originated in view of the above situation, and this invention is a thing.

The purpose is alike, and can certainly and fully wash several Oshi's washed object simultaneously more, and ultrasonic cleaning with a frequency of not less than several MHz is

possible for it, and it is providing the ultrasonic cleaner using the vibrational energy which fully washes a large-sized wafer, a glass substrate, etc. where facility cost does not start comparatively.

[0008]
[Means for Solving the Problem]In order that this invention may attain the above purpose, an ultrasonic vibration body which generates supersonic vibration of the wavelength lambda in a cleaning tank in which a tabular washed object and a penetrant remover are accommodated is arranged, A propagating direction of said supersonic vibration which spreads inside of said penetrant remover intersects said washed object aslant, And in an ultrasonic cleaner constituted so that transmissivity of vibrational energy of said supersonic vibration with which the angle of inclination theta to a normal line direction of a wave receiving surface of this washed object penetrates this washed object might become an angle range improved remarkably, Said ultrasonic vibration body constitutes an ultrasonic cleaner which consists of an aggregate of a vibrator with which it is arranged at said washed object and parallel, and is satisfied of a formula of P=lambda/sin theta, or P<=lambda/sin theta, and which was arranged at intervals of P. Between said each vibrator arranged at intervals of P, and a signal supply source which supplies a driving signal to these, it is characterized by an ultrasonic cleaner with which a phase conversion circuit for ultrasonic wave generations which adjusts a phase of a driving signal inputted into each vibrator is interposed. An ultrasonic vibration body which generates supersonic vibration in a cleaning tank in which a tabular washed object and a penetrant remover are accommodated is arranged, A propagating direction of said supersonic vibration which spreads inside of said penetrant remover at the acoustic velocity V intersects said washed object aslant, And in an ultrasonic cleaner constituted so that transmissivity of vibrational energy of said supersonic vibration with which the angle of inclination theta to a normal line direction of a wave receiving surface of said washed object penetrates said washed object might become an angle range improved remarkably, Said ultrasonic vibration body consists of said washed object, a diaphragm arranged at parallel, and an oscillation element more than a piece attached to this, This oscillation element excites an elastic leaky wave along with said diaphragm with the phase velocity v which fills a formula of v=V/sintheta, and, thereby, adds supersonic vibration to said washed object with said desired angle of inclination theta. Said diaphragm is arranged in said cleaning tank, and said washed object is arranged on both sides of said diaphragm.
[0009]According to the first side of this invention, an ultrasonic vibration body which generates supersonic vibration of the wavelength lambda in a cleaning tank uses an array which arranged two or more vibrators at intervals of P. By [which are asked from a formula of P=lambda/sin theta based on the total penetration angle theta which shows a peak of transmissivity] putting each vibrator in order at intervals of P, From an ultrasonic vibration body as aggregates, such as this, an elastic wave of supersonic vibration of the angle theta can be impressed to a normal line direction of a wave receiving surface of a washed object with a Snell's law. While this elastic wave advances inside of a cleaning tank with the angle of inclination theta, since the ultrasonic vibration body itself can be arranged in parallel to a washed object, even if a size of a washed object becomes long, an interval of supersonic vibration and a washed object becomes fixed. What is necessary is just to make an arrangement change of the ultrasonic vibration body at

intervals of [which was searched for by P=lambda/sin theta based on the total penetration angle theta corresponding to it etc.] P, when board thickness, construction material, etc. of a washed object change. If an interval of a vibration element of an array is formed small and a phase of an electrical signal for an oscillation impressed to each ultrasonic vibrator is relatively adjusted as shown in P<=lambda/sin theta, a cleaning body can be irradiated with ultrasonic energy with sufficient accuracy for arbitrary angles. By providing a diaphragm and an oscillation element attached to this in an inside or paries lateralis orbitae of a cleaning tank instead of the aforementioned ultrasonic vibration body array according to the second side of this invention, A leaky wave of the phase velocity v called for by v=V/sintheta is excited, and since supersonic vibration impressed to a washed object at the angle theta from this leaky wave occurs, certain and sufficient washing is performed like a thing using the aforementioned vibrator array. In this case, if an oscillating condition of an oscillation element is changed so that the phase velocity v may be changed with change of the angle theta according to board thickness and construction material of a washed object, it can respond to ultrasonic cleaning of various board-shaped object articles with one washing station.

[0010]

[Embodiment of the Invention]Hereafter, the ultrasonic cleaner of this invention is explained in full detail with reference to drawings. As shown in drawing 2 in drawing 1, in the penetrant remover inside the box-like cleaning tank 4, several tabular many washed objects 5 are juxtaposed. Many ultrasonic vibrators 1 are arranged at the interval P in the flat one side face of the cleaning tank 4 at array form, and an ultrasonic vibration body is constituted as a whole. Wavelength of the supersonic vibration oscillated from each ultrasonic vibrator 1 is set to lambda, and if the electrical signal impressed to each ultrasonic vibrator presupposes that it is in phase, the expression of relations of P=lambda/sin theta will be materialized between the wavelength lambda, and the interval P and the angle theta. The angle theta is an angle of inclination of the supersonic vibration to the normal method of the wave receiving surface of the washed object 5. This angle of inclination (incidence angle) theta is set as the angle range where the transmissivity shown in drawing 7 becomes about 100 [%], and it asks for P corresponding to this. The angle of inclination theta is called for theoretically as functions (density, acoustic velocity, etc.), such as frequency of the board thickness of the washed object 5, construction material, and the supersonic vibration irradiated, and an elastic constant of a washed object and a penetrant remover, and experimentally, and is called a total penetration angle. It is not necessary to coincide the angle of inclination theta with a total penetration angle correctly actually, and a desired effect is acquired in a fixed angle range.

[0011]If each ultrasonic vibrator 1 is arranged at intervals of P like drawing 1 and drawing 2 and the ultrasonic vibrator 1 is driven, as shown in drawing 2 in the cleaning tank 4, the supersonic vibration of the angle of inclination theta will arise, and vibrational energy will be impressed to the washed object 5. Since the energy of this supersonic vibration has transmissivity close to 100 [%], it can be penetrated without decreasing each washed object 5, and can perform all the washing of the washed object 5. Of course, washing of the rear surface of the washed object 5 is possible. What is necessary is to change the interval P and just to arrange the ultrasonic vibrator 1 so that the angle of inclination theta corresponding to this may arise when the shape of the washed object 5, construction material, etc. change. Since the array of the ultrasonic vibrator 1 can be arranged in parallel to the wave receiving surface 8 of the washed object 5

unlike the thing of the conventional technology shown in drawing 8, uniform vibrational energy can always be impressed all over the washed object 5, and uniform washing can be performed.
[0012]Since the driving signal of the frequency f enters uniformly, without passing a phase conversion circuit from the HARASHIN item supply source (not shown) at each aforementioned ultrasonic vibrator 1, from each ultrasonic vibrator 1, an elastic wave without phase lag is sent in the cleaning tank 4. Drawing 5 and drawing 6 change the phase of the electrical signal impressed to each ultrasonic vibrator 1, and show an example of the embodiment which gives a phase shift to the ultrasonic wave sent in the cleaning tank 4. By giving a phase shift, to the washed object 5, the vibrational energy of an elastic wave is impressed in wavelike, and certain-ization of a cleaning effect is attained more. If such a phase conversion circuit is used, the angle which made the interval P of the ultrasonic vibrator small and was meant more to high degree of accuracy can be irradiated with a directive high ultrasonic wave on the cleaning body surface.
[0013]As shown in drawing 5, the HARASHIN item of the frequency f is sent from the HARASHIN item supply source (figure abbreviation). Between said HARASHIN item supply source and each ultrasonic vibrator 1 provided in the cleaning tank 4, the phase conversion circuit 6 for ultrasonic wave generations is interposed. This phase conversion circuit 6 for ultrasonic wave generations has the function to produce a gap of phase deltat and to impress a driving signal to each ultrasonic vibrator 1, to the HARASHIN item. As shown in drawing 5 and drawing 6, the HARASHIN item of deltat=0 is inputted into the ultrasonic vibrator 1 of ** as a driving signal as it is, and the driving signal which carried out the phase shift only of the $deltat_1$=deltat is inputted into the ultrasonic vibrator 1 of **. The driving signal which shifted only $deltat_3$=3deltat to the ultrasonic vibrator 1 of $deltat_2$=2deltat and ** is similarly sent to the ultrasonic vibrator 1 of **. of course, ultrasonic vibrators 1 other than a graphic display -- one by one -- $deltat_4$ and $deltat_5$ -- the driving signal which carried out the phase shift only of ... is inputted. Phase shifting amount deltat is expressed as deltat=(P/V) andsintheta using P of the array pitch of each ultrasonic vibrator 1, and the acoustic velocity V of a penetrant remover. From each ultrasonic vibrator 1, the elastic wave of the supersonic vibration by which phase adjustment was carried out is emitted with the angle of gradient theta by the above, and is impressed to the washed object 5.
[0014]Drawing 3 shows another embodiment of this invention. The cleaning tank 4 of this example uses the side face plate of thickness d as the diaphragm 3. The oscillation element 2 is attached on the diaphragm 3, and the ultrasonic vibration body is constituted as a whole. If the oscillation element 2 vibrates on the diaphragm 3, to the diaphragm 3, the leaky wave 7 of the phase velocity v will excite. This leaky wave 7 (for example, disclosure Lamb wave) generates the elastic wave of the supersonic vibration of the angle of inclination theta in the tub of the cleaning tank 4. When acoustic velocity of the supersonic vibration which spreads the inside of a penetrant remover is set to V, the phase velocity v of said leaky wave is called for by v=V/sintheta. Therefore, what is necessary is just to decide the oscillating condition of the oscillation element 2 which excites the leaky wave of the desired phase velocity v according to the angle of inclination theta which sets transmissivity of the vibrational energy to the washed object 5 to about 100 [%]. The almost same effect as a precedent can be achieved also with the washing station of this example.
[0015]Drawing 4 is an application of the embodiment shown in drawing 3. In this example, the

diaphragm 3a is arranged inside the cleaning tank 4, and the oscillation element 2 is connected with this. In this case, the washed object 5 is arranged on both sides of the diaphragm 3a at both sides. Also in this example, the leaky wave 7 occurs in the diaphragm 3a, the elastic wave of supersonic vibration is emitted with the angle of inclination theta from the both sides, and the washed object 5 of both sides can be washed uniformly. Here, although the diaphragm has taken the cantilever structure by the oscillation element of a piece, it is already providing the oscillation element of a piece in the confrontation of a diaphragm, and also it becomes possible to add a uniform and powerful ultrasonic wave to a washed object.

[0016]

[Effect of the Invention]1) according to the ultrasonic cleaner of this invention according to claim 1, the elastic wave of the transmissivity 100 [about] [%] is impressed to a washed object with the angle of inclination theta by arranging an ultrasonic vibrator by interval P=lambda/sin theta to array form in a cleaning tank -- many -- the surface of the washed object of several sheets is certainly and fully washed. A washed object can be approached, and a washed object can be uniformly irradiated with an ultrasonic wave with a frequency of not less than several MHz, and improvement in a washing degree can be aimed at.

2) According to claim 2 and the ultrasonic cleaner according to claim 3 of this invention, since phase adjustment of the elastic wave emitted from each ultrasonic vibrator is carried out, positive washing is performed.

3) According to the ultrasonic cleaner of this invention according to claim 4, the leaky wave of phase velocity v=V/sintheta is excited to the vibration body provided in the cleaning tank, entering the elastic wave of the angle of inclination theta into a washed object from this leaky wave, and setting up the angle of inclination theta near the total penetration angle of the transmissivity 100 [about] [%] -- many -- the washed object of several sheets is certainly and fully washed.

4) According to the ultrasonic cleaner of this invention according to claim 5, more nearly equivalent and efficient washing is performed by putting in a vibration body in a cleaning tank directly.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The perspective view showing the ultrasonic vibrator arranged on the side of a box-like cleaning tank at array form.
[Drawing 2]The mimetic diagram showing the propagation state of the supersonic vibration in drawing 1.
[Drawing 3]The mimetic diagram showing the state of providing a diaphragm and an oscillation element in the side of a cleaning tank, exciting a leaky wave, and making supersonic vibration spreading in a tub.
[Drawing 4]The mimetic diagram showing the embodiment which has arranged the diaphragm in drawing 3 in a cleaning tank,
[Drawing 5]The lineblock diagram for changing into the driving signal which carried out the phase shift of the HARASHIN item of the frequency f to the ultrasonic vibrator, and making it input into each ultrasonic vibrator.
[Drawing 6]The wave form chart showing an example of the driving signal in drawing 5 which carried out the phase shift.
[Drawing 7]The diagram showing the relation of the angle of inclination of supersonic vibration and transmissivity which are irradiated by the washed object.
[Drawing 8]The sectional view showing an example of the cleaning method using the conventional angle of inclination theta.
[Drawing 9]The mimetic diagram showing the conventional cleaning method.
[Drawing 10]The mimetic diagram showing the conventional cleaning method.
[Description of Notations]
1 Ultrasonic vibrator
2 Oscillation element
3 Diaphragm
3a Diaphragm
4 Cleaning tank
5 Washed object
6 The phase conversion circuit for ultrasonic wave generations
7 Leaky wave
8 Wave receiving surface

9 Ultrasonic oscillation object

[Translation done.]